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Short Synopsis

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The Effect of Vehicle Servicing on Exhaust Emission: Design and Development of System for Emission Reduction

DEPARTMENT OF AUTOMOBILE ENGINEERING

FACULTY OF ENGINEERING & TECHNOLOGY

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Declaration

This is to declare that this short synopsis reflects the research work design and its contents are the original piece of work, as per guidelines, grammatically correct and free from plagiarism. This has been prepared under the guidance and supervision of my supervisor.

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Recommendation

I recommend this short synopsis prepared and submitted by Mr. Manu Bindra for approval of Ph.D Doctoral Research Board and thereafter to be uploaded on Shodh Gangotri.

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ABSTRACT

Automotive vehicles emit several exhaust gases and pollutants. The largest part of these gases consists of nitrogen (N_2), water vapor (H_2O) and carbon dioxide (CO_2) these are not toxic. Harmful gases i.e carbon monoxide (CO) produced because of incomplete combustion, nitrogen oxides (NO_x) generated at high temperatures, hydrocarbons (HC) obtained from unburnt fuel, particulate matter (PM, mostly soot) and oxides of sulphur (SO_x) due to sulphur content in fuel, are referred as pollutants. These toxic pollutants are responsible for air pollution which further become the cause of respiratory diseases in living beings. To curb this problem of air pollution from vehicles, India is preparing to enforce stricter BS-VI norms by year 2020 skipping BS V norm. One of the important aspects that need to be focused upon for reduced emission levels from vehicles is regular and timely servicing. In the proposed research effect of servicing on the emission will be analyzed on which not much work has been done. A suitable sample size of gasoline vehicles will be selected. There emission data at different service points will be collected during the life cycle of the vehicle. The cause of more emission if any due to irregular service will be identified & analyzed. This will also be compared with vehicles that undergo recommended schedule of regular servicing. As new emission reduction technologies are to be used in BS VI gasoline vehicles, some studies will be made on device / technology that will come up in BS VI vehicles. With the help of new approach, new work on automotive tail pipe emission reduction device will be conducted. Result from this developed device will be analyzed and compared.

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THE EFFECT OF VEHICLE SERVICING ON EXHAUST EMISSION: DESIGN AND DEVELOPMENT OF SYSTEM FOR EMISSION REDUCTION

I. INTRODUCTION

The importance of road transport in economic growth by transporting goods and people across the country is very well recognized. At the same time, it is an important source of pollution of ambient air and there is an urgent need to check the extent of vehicular pollution, especially since there has and is likely to continue to be a large increase in the stock of road vehicle traffic in the country. Emissions because of road transport can be categorized as Direct i.e. generated during operation of vehicles (Tail pipe emissions and evaporative losses) or as Indirect i.e. as generated during the production of fuel, manufacturing and disposal of vehicle. Various studies undertaken have shown that out of total transport lifecycle emissions, the share of tail pipe emissions is quite significant i.e. more than 50% of total lifecycle emissions [1] vehicular exhaust. Between 2000 and 2013, air pollution levels increased dramatically across India [2]. Therefore an effort in reduction of harmful emissions from the tail pipe of vehicles shall contribute substantially in reducing total inventories of Global Green House Gases.

Tail pipe emissions from an internal combustion engine comprises mainly carbon dioxide CO_2, Carbon mono-oxide CO, un-burnt Hydrocarbons HC, Nitrogen oxides NOx and Particulate matter PM. In a typical petrol engine vehicle, the major components of harmful tail pipe emissions are CO_2, CO & HC whereas a diesel engine vehicle produces significant quantities of CO_2, NOx & PM [2]. With the increased density per unit area of vehicles, high levels of tail pipe emissions of Nitrogen oxides NOx and Particulate matter (mainly carbon) has caused health concerns for respiratory and cardiovascular problems. [3] [4]. Diesel engines suffer from the disadvantages of harmful pollution causing exhaust, namely nitrogen oxides (NOx) and particulate matter (PM) which are facing increasingly stringent emission regulations.

Vehicular emission standards which were notified in the year 1991 for the first time in India, BS Emissions norms so devised were meant for regulating air pollution from generators and engines. Central Pollution Control Board is the devising agency for BS standards who took European regulations as base line. Responding to the growing concern for alarming rise of vehicular emission pollution, govt. of India has decided to leapfrog from BS IV to BSVI norms by year 2020, skipping BS V. These norms have become more and more stringent over the period of time.

A comparative table has been presented in Tables 1 and 2 depicting the BS-IV and BS-VI emission standards for petrol and diesel vehicles. For BS VI norms Particulate matter is measured in terms of number of particles emitted per kilometer.

Table 1. Petrol engine emissions in g/km

Emission norm	CO	HC	NOx	PM
BS-III	2.3	0.2	0.15	na

Table 2. Diesel engine emissions in g/km

Emission norm	CO	HC	NOx	HC + NOx	PM
BS-III	0.64	na	0.5	0.56	0.05

BS-IV	1	0.1	0.08	na	BS-IV	0.5	na	0.25	0.3	0.025
BS-VI	1	0.1	0.06	$6*10^{11\#}$	BS-VI	0.5	na	0.06	0.17	$6*10^{11\#}$
Number of particles per Km					(The data presented is for M&N category vehicles with GVW<3.5 tons.)					

Observing the table it is noted that there is no change in the values of CO and HC emission but the values for NO_x and PM are on the lower side for BS VI norms. Similarly in diesel engines emission, there are reduction in the NO_x, HC + NO_x and PM for BS VI norms.

This was mostly achieved by improving combustion efficiencies through improvement / modifications in IC engine designs and after treatment technologies. [5]. These increasingly demanding regulations have led to the search for alternative technologies in order to control harmful vehicle emissions, such as fuel modification, combustion process modification and exhaust gas after treatment. Technologies for improved emission control are shown in the table 3

Table 3. Technologies used in petrol & diesel engines for improved emission control [61]

Technologies used in petrol engines for improved emission control		**Technologies used in diesel engines for improved emission control**	
In cylinder control	• Air fuel management for cold start control on fuel injection, engine valve train optimization and turbocharging. • Incremental improvements to combustion system. • Exhaust gas recirculation (EGR) with electronic control systems.	**In cylinder control**	• High pressure fuel injection (up to 1900 bar) • Variable geometry turbines for improved air fuel management. • Variable valve timing and fuel injection for regeneration of diesel particulate filter. • Continuous R&D for combustion system improvement. • Exhaust gas recirculation with DC motor actuator
After Treatment	• Improvements to three way catalytic converter (3WCC) operation. • Use of gasoline particulate filters (GPFs) for direct injection engines	**After Treatment**	• PM after treatment with diesel particulate filters and diesel oxidation catalysts. • NO_x reduction based on selective catalytic reduction (SCR) or lean NO_x traps (LNT).

Improvements and modification processes of engine design and operations are a costly affair. Also such changes are generally achieved at the manufacturer level and are mostly implemented for further production of vehicles. There is a large inventory of vehicles already

under use which were manufactured for lower levels of regulatory compliances which also need to be upgraded to stricter BSVI emission norms. Therefore, the emission control techniques / systems comprising of after treatment of vehicle exhaust assumes significance as these systems can be suitably adapted for retro fitment in existing fleet of on road vehicles.

II. LITERATURE REVIEW

a. Tail pipe emission reduction techniques / after treatment of exhaust gases

At present, a considerable amount of effort is being directed towards providing apparatus for efficient removal of emission pollutants from engine exhausts, both noxious gases and particulate matter .Two methods, Selective Catalytic Reduction systems and Diesel Particulate Filter, for controlling diesel emissions are being widely used, either independently or together, for meeting increasingly stringent emissions regulations worldwide.

The principal method for advanced NOx control is Selective Catalytic Reduction (SCR).A variety of SCR catalysts have been developed over the years for effective NOx reduction. These include vanadium based catalysts and advanced zeolite based catalysts, in different emission control systems. Vanadium SCR catalysts have demonstrated high performance and excellent durability. For systems with high temperature active DPF regeneration, either Cu-zeolite based or Fe-zeolite based SCR systems have been successfully used due to their high temperature durability (>600°C).

These systems, DPF and SCR, help in reducing emission pollutants namely particulate matter and nitrogen oxides. The results show that the DPF and SCR systems were capable of substantially reducing PM and NO_x emissions, respectively .It is suggested that a combination of the two systems in engine applications would help in substantially reducing tail pipe emissions simultaneously

b. NOx Reduction Processes

Many researches were undertaken in several issues related to NOx and its reduction methods. Some of the researches and developments on NOx reduction in the exhaust (through after treatment) are briefly reviewed. NOx formation is mainly attributed to high temperature of burnt gases during combustion and the duration for which the burnt gases remain in those temperatures. NOx is produced when Nitrogen reacts with Oxygen inside the combustion chamber of IC engine. This chemical reaction happens at temperatures higher than 1800^{o} K through dissociation of nitrogen and oxygen molecules as below:

$$N2 \rightarrow 2N$$
$$O2 \rightarrow 2O$$
$$N + OH \rightarrow NO + H$$
$$NO + OH \rightarrow NO2 + H$$
$$NO2 + O \rightarrow NO + O2$$

More the time for oxidation at higher temperatures, more is the NOx produced. Therefore reduction in temperature during combustion as quickly as possible, helps in retarding the formation of NOx.

NOx Reduction through EGR-Exhaust Gas Re-Circulation

Experiments by introducing the exhaust gas recirculation (EGR) system and water injection at a pressure of 0.3 MPa through the inlet manifold were also conducted. Exhaust gases are

cooled before being injected back into the combustion chamber. This helps in lowering the temperatures of the combustion process. Konno et al [18] observed that the introduction of EGR and water reported a lower generation of NOx and PM. NOx reduction of 72% was achieved with the water injection when engine load is more and EGR is more effective at low load conditions.

Larsen et al [24] studied the optimal use of filtered exhaust gas recirculation (EGR) to reduce the NO emissions of diesel engines. They stated that control of the particulate emissions and provisions for filtered EGR were achieved by an Aerodynamically Regenerated Trap (ART) with collection efficiencies in the order of 99%. It was reported that EGR regulation was accomplished by monitoring the injection pump setting which was correlated to the fuel flow rate, the speed of the engine, the amount of EGR flow, and the ambient air temperature. It was concluded that NOx emissions was effectively reduced at 20% EGR, with a loss in fuel economy by 8%. It was also concluded that with electrically controlled EGR valve, the NOx level was decreased by 30%.

Akira Murakami [25] developed a new combustion chamber, in which a strong turbulence is created in the middle and late stages of combustion that enhanced smoke oxidation to achieve simultaneous reduction of NOx and smoke from diesel engines. It was concluded that the NOx was reduced as the disturbance shortened the combustion duration.

NOx reduction through After-Treatment of Exhaust Gas

Held et al [26] studied the NOx reduction using copper exchanged zeolite catalysts on a lean-burn spark-ignition engine as well as diesel engine. They stated that a NOx conversion ratio of approximately 45% was achieved for S.I engine and a 65 % NOx reduction was achieved in the case of diesel engines. It was found that copper exchanged zeolite catalyst was more effective in control of NOx at wide range of load conditions as compared to other noble metal catalysts. It was concluded that either ammonia or urea can be used as reducing agent. Walker and Speronello [27] investigated on a larger diesel engine driven by natural gas using ammonia injection for the reduction of NOx emissions from the engine exhaust to develop an exhaust gas treatment system. It was concluded that the NOx was reduced by 80 % and an ammonia slip of less than 2ppm was achieved although the engine performance reduced slightly.

Muramatsu et al [28[studied the reduction of NOx from diesel engine exhaust using a newly developed copper based catalyst system. It was concluded that the newly developed catalyst system combined with a diesel fuel or heavy saturated hydrocarbon spray system effectively reduced the NOx by 20%-30%. Kawanami et al [29**]** investigated the performance of several catalytic systems with respect to NOx was examined when secondary hydrocarbons were added as reducing agent directly in the exhaust gas stream. It was concluded that generation of NOx and PM reduced by 12% & 25% respectively depending on amount and choice of catalyst**.** Oey et al [30] studied the simultaneous control of particulate and NOx emissions from diesel engines. A high-filtration efficiency ceramic honeycomb monolith was used to control particulate. The soot collected in a metallic chamber was either incinerated by an electric burner or removed by vacuum cleaner. Further circulation of filtered exhaust gases (EGR) was used to reduce NOx emissions. It was concluded that the introduction of 20% EGR reduced the NOx emission by 50% at average

loads.Willand et al [31] experimented with a heavy duty single cylinder engine using aqueous urea as reducing agents for the NOx reduction as an selective non catalyst reduction process.The aqueous urea was directly introduced into the combustion chamber. It was reported that a NOx generation reduced by 65%. Koebel et al (32] studied the use of urea injection selective catalyst reduction for heavy duty truck engine.

Nam et al [33] conducted NOx reduction experiments over a wide range of air/fuel ratios (20-40) on a diesel fueled single cylinder engine.About 40% - 60% reduction of NOx was achieved. It was reported that the injection of secondary combustible additives (diesel/C2H6) into the exhaust pipe promoted further substantial NOx reduction (5% - 30%). Lambert et al [34] investigated the reduction of NOx with selective catalytic reduction technique using aqueous urea in a diesel vehicle. A diesel particulate filter was fixed in the engine exhaust system before the Selective Catalytic Reduction system to reduce the particulate matter and high way tests were performed to analyze the emissions at various exhaust temperature. It was concluded that the vehicle exhaust met the emission standard (0.2 g/mi NOx and 0.04 g/mi particulate matter (PM). Blakeman et al [35] investigated the potential of urea based SCR for NOx reduction on a light duty vehicle. The investigations were carried out to study the various effects by placing the oxidation catalyst at different positions in the system by varying the SCR catalyst composition and the rate of urea injections. It was concluded that, in the investigation, it achieved a maximum NOx reduction of 73%.

Gekas et al [36] used a novel urea injection system, by automatically controlling the process through electronically controlled pump. NOx conversion achieved in their experiment was above 80%. Van Helden et al [37] investigated the NOx reduction using vanadium catalyst with urea injection in Heavy duty truck Diesel Engine. Their systemachieved62% reduction of NOx from the exhaust gases. It was further reported that even after 60,000km operation, NOx conversion and Ammonia slip remained same. It was concluded that, such a catalyst arrangements could be used to achieve an optimal NOx conversion in practical. Nakatami et al [38] developed a new after treatment system, diesel particulate NOx reduction system (DPNR). It was claimed that more than 80 % of both NO and particulate matter was achieved with the DPNR developed. Schar et al [39] investigated the NOx reduction control of urea SCR catalytic converter system for a mobile heavy duty engine using titanium dioxide and claimed 82 % NOx reduction was achieved.

Rusch et al [40] investigated different particulate measuring technologies on the influence of parameters like the sulfur content of the fuel and the reducing agent. It was found that with the use of a SCR system, a clear decrease of the nano particulate emissions was achieved under all dosing conditions**.** Tennison et al [41] studied the use of an oxidation catalyst to convert engine exhaust HC and CO upstream of the urea SCR system. They stated that aqueous urea was added to the exhaust using a Ford developed air assisted injection system. It was stated that a base metal / zeolite SCR catalyst was utilized to convert NOx to N2 under lean. Schmieg and Lee [42] investigated the selective catalytic reduction of NO using urea (urea-SCR) as one of the promising technologies for removing NOx from diesel engine exhaust. They stated that the NOx in the engine exhaust was reduced by ammonia derived from urea over a catalyst to N2.The performance of three different catalyst

formulations (Cu-zeolite, Fe-zeolite, Vanadium-based) were studied to obtain useful guidance in the design and operation of urea-SCR lean NOx emission control systems.

Servati et al [43] investigated the performance of a selective catalytic reduction (SCR) after treatment system designed for diesel retrofit applications.As part of the system, a compact air-assisted dosing unit was developed for effective urea delivery and atomization. It was concluded that an overall NOx reduction of 70 % was achieved. Itabashi et al [44] developed a system that simultaneously reduced NOx and particulate emission from diesel engine. It was found that there was an improvement in NOx reduction performance and a decrease in the loss of fuel economy from the NOx reduction. Nishioka et al [45] developed a urea dosing device with two injectors to enhance the NOx reduction at low exhaust temperatures and also to lower the electric power consumption of the SCR system. One injector was located on the wall of the main exhaust duct for directly supplying urea to the exhaust and the other injector was used to supply urea to a bypass passage connecting the exhaust during low exhaust temperatures. Lee et al [46] examined urea-SCR system using flow visualization techniques in a heavy duty diesel engine to determine the optimal urea injection condition by conducting a parametric study on gas temperatures, space velocity and aspect ratio.

Murata et al [47] investigated the development of a urea SCR system combined with a diesel particulate filter system to reduce NOx and PM in a four liters turbocharged with intercooler diesel engine. They reported that significant NOx reduction was observed at low exhaust gas temperatures by increasing NH3 adsorption quantity in the SCR catalyst. It was concluded that they have developed a urea SCR system that could reduce NOx by 75%. Rajadurai [48] studied the effect of compact, knitted, crimped wire mesh mixer fixed between the reducing agent injection and the urea SCR unit of a diesel engine. With modified geometry and channel dimensions of the wire mesh provided zigzag path for the gas flow to obtain efficient mixing. It was concluded that about 10-30% improvement in NOx reduction was achieved.

Conclusion on NO_x reduction

From the research literature referred to as above, it is noted that considerable experimental and theoretical investigations have been carried out on the control of NOx emission from diesel engine Among the three techniques reviewed above, the exhaust gas after treatment system is preferred due to its less cost and simplicity compared to the other two methods. A variety of SCR catalysts have been developed over the years for effective NOx reduction, whereas promising results have been achieved with the method of SNCR using urea as reductant.Also it has been stated by many studies that with the reduction in temperature of exhaust gases , the efficiency of catalyst reduction in NOx increases thereby achieving more reduction in NOx levels.Also, the EGR technique is now a commercially acceptable technology to reduce NOx and is widely used in diesel engine vehicles.

c. Particulate Matter (PM) Reduction Techniques

Composition of Exhaust gases of internal combustion engines comprises particulate matter - mostly soot (in excess of 50%) and unburnt or partially burnt fuel/ lubricating oil, fuel derived sulfates, metal from wear and tear and bound water.

Existing tail pipe exhaust systems do not cater to the removal of particulate matter, and are released into the ambient air [49]. The Bharat VI emission regulations have been proposed for implementation from year 2020 for the Indian automotive industry. This will require PM reduction systems like DPF (Diesel Particulate Filter) employing cyclone separators, baffle systems, filters, etc.

In the case of diesel Engines three devices i.e Catalytic converter, Diesel Particulate Filter (DPF) and Selective Catalytic Reduction (SCR) are fitted in series. Although catalytic convertor is there in BS IV vehicles two extra devices DPF and SCR are to be fitted extra to make vehicle BS VI compliance vehicle [13,18,19].

PM Reduction Processes/Techniques

- Catalytic convertor technique
- Filter mesh technique
- Centrifugal separator technique

Particulate Matter Catalytic Convertor Technique

The most commonly used catalytic converter technique for compression ignition engines is the use of oxidation process. The oxidation catalyst reduces particulates by oxidizing the HC portion of the PM and wall maze traps the soot and ash constituents. The catalyst uses excess O2 in the exhaust gas stream to oxidize CO to CO2 and HC to H2O and CO2. These converters often reach 90% effectiveness, virtually eliminating diesel odor and helping to reduce visible particulates (soot).

Tulleners et al [50] patented a design where alkaline compounds , bauxite etc are made to react with acidic elements .These chemical reactions lead to formation of aggregates of larger sizes which being heavier get separated from gaseous flow.

Lenane D.[51]in his patent used alumina compound to react with uncondensed compound like lead halides in an exclusive chamber fitted in the tail pipe before the baffle filter.Such course alumina particulates are then separated in the muffler trap particulate separator.

An improvement in exhaust particulate filters was suggested by Smith JM.[52]. There was a limitation as to the size of the filter that can be fitted in the tail pipe of an engine exhaust.His design also attempted to address the problem of back pressure on the engine due to clogging of filters.He designed a filter having two parallel flow tubes.The gaseous flow is regulated through a filter via a main tube which acts as a shunt tube.In an another invention by Herman et al [53], exhaust gases flow through an intake pipe of substantial length leading to increased number of collisions between carbon particles resulting into increased subsequent agglomerations. The larger agglomerated carbon particles and the exhaust gases may then pass through a diffuser manifold in which is located a number of diffuser chokes to add further turbulence in the flow and, which leads to further agglomeration of the carbon particles. The diffuser manifold then distributes the agglomerated carbon particles and the exhaust gases uniformly on a filter cartridge using a pleated filter material for trapping the diesel particulate material. The pleats also provide larger surface area for depositing the diesel soot, which further aids filtering. The cartridge has inside-out flow so that the diesel soot is deposited on the inside of the cartridge. The cartridge may be capped and removed for cleaning and reuse.

The life of such catalysts is limited by several factors, one of which is that the catalyst bed tends to become plugged or deactivated by the particulate matter contained in exhaust gas. This results in an increase in back pressure in the exhaust system and decreased catalytic activity.

Particulate Matter Traps/Filters Technique

There are various types of diesel particulate filters using continuous regeneration methods.The DPF typically comprises a combination of oxidation catalyst and active particle filter.The catalyst is placed before the particle filter trap in the flow of exhaust gases.The catalyst converts NOx into NO2 which helps in continuous regeneration of the filter by accelerating the oxidizing and burning the soot deposits at lower temperatures in the exhaust tail pipe.

Shiro et al [54] explained a design in their patent for carbon particle reduction apparatus which comprises a honeycomb core coated with an oxidation catalyst like platinum and plurality of metal filters having a wire mesh structure.The catalyst oxidizes, burn and then eliminate CO,HC, etc., and also convert NO of the exhaust gas to NO2.Wire mesh structure captures, accumulate, oxidize, burn, reduce and/or eliminate the carbon particles from the exhaust gas by a selective combination of (a) essential adoption of one or more filters with a wire mesh structure, (b) adhesion and coating of an oxidation catalyst such as platinum to the filters, (c) adoption of a plurality of filters having different mesh densities, (d) spaces in a lateral direction between the filters, a small amount of the carbon particles is first captured and accumulated by the filters, and soon oxidized and burnt, regenerate in order to be continuously used thereafter.

Particulate Matter Centrifugal separators Technique

In this kind of PM separators, exhaust gaseous flow is made to follow a circular path.This kind of circular path for the gaseous flow is generraly achieved by leading the flow tangentially inside the separator.This brings into play centrifugal forces acting on the gaseous flow alongwith the particles contained therein.Because of resulting differential inertial forces, the particles follow a different trajectory and get separated from the gaseous flow along with the walls of the filter.

Hortman, N. [55] designed a PM separating device comprising of a smaller diameter duct, placed inside a larger diameter duct.The exhaust gases are lead through inletof smaller diameter tubetube which acts as inlet for the exhaust gases.A wedge like structure is placed at the mouth of this duct which converts the flow into a spiral flow.This flow of medium gets converted into a helix as it flows through the helical vanes in the casing.The particles get separated from the gaseous flow due to different inertial centrifugal forces and are captured in a lining of porous material like asbestos (which is heat resistant and easily disposable), inside of the casing.

Jacobs et al [56] patented a design of aparticulate matter separating device using a combination of chemical absorption and centrifugal separation techniques. The refractory alumina provides sites for condensation, particle nucleation and agglomeration. After leaving the beds of alumina, The exhaust gas stream enters the cyclone separators and particulate matter gets separated. Efficiency of the system was reported to be more than 80 percent in removing particulate matter.

The Curved duct PM separator using the above principle of different inertial forces is not very useful for removal of very fine particles.Another design on these lines was suggested by Linhardt H.D. in which velocity of the gaseous flow was accelerated upto a minimum speed equivalent to the speed of sound.This acceleration of gaseous flow causes drop in static pressure resulting into condensation of condensable elements in the gaseous flow.These condensates trap fine particles creating large sized aggregates which then get separated through centrifugal action [57].

Lardinois P. [58] invented a process for extraction of particles from a gaseous carrier fluid, under the form of particles like solid particles or drops.The carrier fluid is forced to flow to a high velocity into a separating device in which it is forced to follow a bent path resulting in separation of particles under the effect of the centrifugal forces acting on the particles.The gaseous fluid flows through a nozzle of a convergent-divergent type having a converging and a diverging channel portion in order to subject the flow to an adiabatic expansion involving a sub-cooling of the gaseous fluid with a pressure decrease.The sub-cooling reaches a critical sub-cooling value at which nucleation of the liquefiable substance occurs in the form of drops having a relatively large diameter and the liquefied substance from the carrier flow are separated by effect of inertial forces exerted .

III. OBJECTIVES OF THE STUDY

Fine particles smoke, CO_2, CO, NO_x, HC etc emitted from vehicles enter into the atmosphere by mixing in air. When inhaled they can harm respiratory and circulatory health, especially in the young, the elderly and those with pre-existing health conditions. This requires immediate and special attention. Less pollution means reduced risk of harmful gases on health. So far large amount of work is being done at the manufacturer's level in design for reduction in emissions however emission levels so achieved are declared at standard test conditions. During the life span of more than 10 years the vehicles has to operate under variable harsh operating conditions i.e climate, road types and gradients, load, maintenance of vehicle etc. A very little information about effect of servicing and maintenance on vehicle emission is available during the operational life span of the vehicle in the literature. With this in the background the study will have the following objectives:

1. To study and analyze the techno, economic and social repercussions of harmful vehicular emissions.
2. To review the existing methods and techniques to control vehicular tail pipe emission.
3. To collect experimental data by measuring the emission levels of gasoline vehicles at different intervals. These findings for serviced and un-serviced vehicles will then be analysed & compared. How well the emission control devices work for any un-serviced and serviced vehicle will also be taken care off in the study.
4. To study the available technology for shifting from BS IV to BS VI Norms.
5. To study the major challenges that is faced by auto and oil sector for bringing this change.
6. To analyze how the emission parameters behave if the vehicle is not serviced as per the manufacturers schedule over different duration.

7. To device a retro fitment system for reduction of vehicle emission of Particulate Matter in compliance to BS VI standards.

IV. METHODOLOGY

a. Extensive experimental data of vehicle emission under different conditions to be collected.
b. Relationship between various variables will be established.
c. Mathematical permutation model for the relationship between various emission factors will be hypothesized
d. Parameters for various factors shall be established and calibrated for the Model, based on the experimental data collected.

1. **Sample selection**:

Based on their share in the total car pool and its mass use, MSIL car models WagonR, Swift, Alto (petrol and MPFI versions) have been selected for the study.

2. Data collection:

a. Data parameters like Registration no. and Age of vehicle, odometer reading etc shall be collected.
b. Service schedules/history of the subject vehicles shall be compiled with respect to Service intervals based on time as well as odometer readings.
c. Data shall be compiled with respect to replacement of service parts like engine oil,oil fiter,fuel filter,air filter spark plugs which are directly effecting proper tuning of the engine.Time intervals as well as mileage done shall be noted.
d. Data shall also be compiled for the frequency of service jobs done on the subject vehicles for Injector cleaning and Throttle body cleaning as these parameters also directly effect engine tuning and efficient combustion process.
e. Measured values of subject vehicle's emission parameters namely CO & HC shall be recorded.

Parameters pertaining to history of servicing of vehicles to be recorded as per following format:

Vehicle Registration No															
Servicing		**Engine Oil**		**Oil Filter**		**Fuel filter**		**Air filter**		**Spark plug**		**Injecytor cleaning**		**Throttle body cleaning**	
Date	KM	Date	KM	Date	KM	Date	KM	Date	KM	Date	KM	Date	KM	Date	KM

Parameters pertaining to emission values of the vehicles to be recorded in following format

Sno	Date of Test	Regn No	Model	Year of Mfr	Odometer reading	CO (%vol)	HC (ppm)

3.Data Analysis:

Based on service schedule parameters data, statistical analysis shall be done to ascertain subject vehicle's adherence to manufacturer recommended schedule.

V PROPOSED OUTCOME

The analysis so developed shall be useful in our ability to compare the impact of different emission factors and ascertain the sensitivity of vehicle emission to each of these factors.

- This comparison shall explain how different factors influence vehicle emission and which factors are more influential.
- Emission analysis so developed will simulate the vehicle emission process over a period of time and thus help in planning for emission reduction strategies by optimizing focus on most critical factors.
- The detailed statistical analysis of comparison of emission values with respect to adherence or deviation from the manufacturer recommended servicing schedule shall provide evidence to our hypothesizes as to the effect of servicing of vehicle on its emission levels.
- This Study will help in planning for emission reduction strategies by optimizing focus on most critical factors.

Based on this research papers in international journals will be published.

A retrofitment system shall be devised to reduce Particulate Matter of petrol vehicles to make the vehicle compliant under proposed BS VI emission norms for which patent will be applied.

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TIME LINE FOR PHD RESEARCH

Time line for major five activities is given below in the form of chart.

Sr. No.	Activity	2017												2018												2019											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
1	Literature Survey																																				
2	Data Collection																																				
3	Select of Analytical Techniques/Methods																																				
4	Data Analysis with inferences and suggestion																																				
5	Thesis Preparation and submission																																				

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